CLAIMS

1. A jitter measuring apparatus comprising:

an orthogonal signal generating unit which converts a signal to be measured into two orthogonal

5   signals which are two signals whose phases are orthogonal to one another;

an instantaneous phase calculating unit which calculates an instantaneous phase based on the two orthogonal signals converted by the orthogonal signal

10   generating unit within a range between a lower limit phase value set in advance and an upper limit phase value set in advance;

a differential value detecting unit which detects a differential value of the instantaneous phase

15   calculated by the instantaneous phase calculating unit;

a differential value correcting unit which corrects the differential value of the instantaneous phase, and which outputs a corrected differential value when the differential value of the instantaneous phase

20   detected by the differential value detecting unit is over the range dependent on the lower limit phase value and the upper limit phase value;

an offset component eliminating unit which elimi-nates an offset component included in the corrected

25   differential value from the corrected differential value output by the differential value correcting unit, and which outputs a differential value from which the

offset component has been eliminated; and

an integration unit which determines a jitter amount of the signal to be measured by integrating the differential value which is output by the offset component eliminating unit, and from which the offset component has been eliminated.

2.   The jitter measuring apparatus according to claim 1, wherein

a lower limit and an upper limit of the range dependent on the lower limit phase value and the upper limit phase value are respectively equal to or approximately equal to the lower limit phase value and the upper limit phase value.

3.   The jitter measuring apparatus according to claim 1 or 2, wherein

the differential value correcting unit has

a discontinuous point detecting unit which detects the differential value of the instantaneous phase as a discontinuous point of the differential value of the instantaneous phase when the differential value of the instantaneous phase detected by the differential value detecting unit is over the range dependent on the lower limit phase value and the upper limit phase value, and

a continuity insuring unit which insures continuity of the differential value of the instantane-ous phase by correcting a discontinuous point of the differential value of the instantaneous phase detected

by the discontinuous point detecting unit with respect
to the differential value of the instantaneous phase
detected by the differential value detecting unit, and
outputting the corrected differential value.

5   4.   The jitter measuring apparatus according to
claim 1 or 2, wherein

the differential value correcting unit has

a discontinuous point detecting unit which detects
the differential value of the instantaneous phase as

10   a discontinuous point of the differential value of the
instantaneous phase when the differential value of the
instantaneous phase detected by the differential value
detecting unit is over the range dependent on the lower
limit phase value and the upper limit phase value, and

15   a discontinuous point eliminating unit which
eliminates the discontinuous point of the differential
value of the instantaneous phase detected by the
discontinuous point detecting unit with respect to the
differential value of the instantaneous phase detected

20   by the differential value detecting unit and outputs
the eliminated differential value.

5.   The jitter measuring apparatus according to
claim 1 or 2, wherein

the differential value correcting unit has

25   a discontinuous point detecting unit which detects
the differential value of the instantaneous phase as
a discontinuous point of the differential value of the

instantaneous phase when the differential value of the
instantaneous phase detected by the differential value
detecting unit is over the range dependent on the lower
limit phase value and the upper limit phase value, and

5   a discontinuous point interpolating unit which
substantially insures continuity of the differential
value of the instantaneous phase by eliminating the
discontinuous point of the differential value of the
instantaneous phase detected by the discontinuous point
10   detecting unit with respect to the differential value
of the instantaneous phase detected by the differential
value detecting unit and interpolating the eliminated
portion and outputting the interpolated differential
value.

15   6.   The jitter measuring apparatus according to
claim 1, wherein
        the offset component eliminating unit has
        a memory in which a value determined by an
operation of $2\pi(fc/fs)$ showing the offset component is
20   stored in advance when a frequency fc of the signal to
be measured and a sampling frequency fs for sampling
the signal to be measured have been already known, and
        a subtraction unit which subtracts the value
showing the offset component stored in the memory
25   from the corrected differential value output by the
differential value correcting unit.

        7.   The jitter measuring apparatus according to

claim 1, wherein

the offset component eliminating unit has

a mean value calculating unit which determines

a mean value of the corrected differential value output

5   by the differential value correcting unit as an offset

component in advance when a frequency fc of the signal

to be measured and a sampling frequency fs for sampling

the signal to be measured have been unknown, and

a subtraction unit which subtracts the mean

10   value of the corrected differential value serving as

the offset component determined by the mean value

calculating unit from the corrected differential value

output by the differential value correcting unit.

8.   The jitter measuring apparatus according to

15   claim 1, wherein,

when a lower limit frequency fj of a jitter

component which is an object to be detected is

designated, the offset component eliminating unit

includes a high-pass filter which has a frequency equal

20   to or approximately equal to the lower limit frequency

fj of the jitter component which is the object to be

detected as a cutoff frequency for eliminating the

offset component from the corrected differential value

output by the differential value correcting unit.

25   9.   The jitter measuring apparatus according to

claim 1, wherein,

given that a digital signal sequence of the signal

to be measured is x(n), a frequency and an amplitude of the signal to be measured are respectively fc and Ac, a sampling frequency for sampling the signal to be measured is fs, and an initial phase and a jitter of

5   the signal to be measured are respectively θc and φ (n), n=0,1,2, ..., and when I(n), Q(n) serving as the two orthogonal signals are respectively expressed by

$$I(n)=x(n)=Ac \cdot cos \ [2\pi(fc/fs)n+\theta c+\phi(n)],$$

$$Q(n)=Ac \cdot sin \ [2\pi(fc/fs)n+\theta c+\phi(n)],$$

10 and Θ(n) serving as the instantaneous phase is expressed by

$$\Theta(n)=tan^{-1} \ [Q(n)/I(n)]$$

$$=2\pi(fc/fs)n+\theta c+\phi(n),$$

the instantaneous phase calculating unit calculates

15 Θ(n) serving as the instantaneous phase determined by an operation of the tan^{-1} [Q(n)/I(n)] within a range from $-\pi$ to π, or $-\pi/2$ to $\pi/2$ as a range between the lower limit phase value set in advance and the upper limit phase value set in advance.

20   10. The jitter measuring apparatus according to claim 9, wherein

        the differential value detecting unit calculates ΔΘ(n) serving as the differential value of the instantaneous phase calculated by the instantaneous

25 phase calculating unit, by an operation of

$$\Delta\Theta(n)=\Theta(n)-\Theta(n-1)$$

$$=2\pi(fc/fs)+ \ \phi(n)-\phi(n-1) \ (Where, \ \Theta(n-1)=0, \ and$$

here, $2\pi(fc/fs)$ is a constant and an offset component).

11. The jitter measuring apparatus according to claim 10, wherein

the differential value correcting unit carries out arithmetic processing of

$$\Delta\theta(n)=\Delta\Theta(n) \qquad (-\pi\leq\Delta\Theta(n)\leq\pi),$$

$$\Delta\theta(n)=\Delta\Theta(n)+2\pi \qquad (-\pi>\Delta\Theta(n)),$$

$$\Delta\theta(n)=\Delta\Theta(n)-2\pi \qquad (\Delta\Theta(n)>\pi)$$

or

$$\Delta\theta(n)=\Delta\Theta(n) \qquad (-\pi/2\leq\Delta\Theta(n)\leq\pi/2),$$

$$\Delta\theta(n)=\Delta\Theta(n)+\pi \qquad (-\pi/2>\Delta\Theta(n)),$$

$$\Delta\theta(n)=\Delta\Theta(n)-\pi \qquad (\Delta\Theta(n)>\pi/2)$$

with respect to $\Delta\Theta(n)$ serving as the differential value of the instantaneous phase in order to calculate $\Delta\theta(n)$ serving as the corrected differential value corrected so as to insure continuity by correcting the discontinuous point of $\Delta\Theta(n)$ serving as the differential value of the instantaneous phase calculated by the instantaneous phase calculating unit.

12. The jitter measuring apparatus according to claim 11, wherein the offset component eliminating unit eliminates the offset component $2\pi(fc/fs)$ from $\Delta\theta(n)$ serving as the corrected differential value corrected so as to insure the continuity by the differential value correcting unit, and outputs

$$\Delta\phi(n)=\phi(n)-\phi(n-1)$$

as $\Delta\phi(n)$ serving as the differential value from which

the offset component has been eliminated to the
integration unit.

13. The jitter measuring apparatus according to
claim 12, wherein

the integration unit

carries out a following integration

$U(n) = \Sigma \Delta\phi(i)$ (Where, the symbol Σ denotes the sum
total of $i=0,1,2, \ldots, n$, and here, provided that $U(n)$
is theoretically expanded, it is made to be

$U(n) = [\phi(0) - \phi(-1)] + [\phi(1) - \phi(0)] +$
$[\phi(2) - \phi(1)] + \ldots \ldots \ldots + [\phi(n) - \phi(n-1)]$

$= \phi(n) - \phi(n-1)$ with respect to $\Delta\phi(n)$ serving as
the differential value which is output by the offset
component eliminating unit, and from which the offset
component has been eliminated, and

here, given that $\phi(-1) = 0$, an integrated result $U(n)$ is
to express a jitter component $\phi(n)$ of the signal to be
measured, and

outputs the integrated result $U(n)$ as the jitter
component $\phi(n)$ of the signal to be measured.

14. A jitter measuring method comprising:

a step of converting a signal to be measured into
two orthogonal signals which are two signals whose
phases are orthogonal to one another;

a step of calculating an instantaneous phase based
on the two orthogonal signals converted by the step of
converting into the two orthogonal signals within a

range between a lower limit phase value set in advance
and an upper limit phase value set in advance;

a step of detecting a differential value of
the instantaneous phase calculated by the step of
5   calculating the instantaneous phase;

a step of correcting the differential value of
the instantaneous phase, and outputting a corrected
differential value when the differential value of the
instantaneous phase detected by the step of detecting
10   the differential value of the instantaneous phase is
over the range dependent on the lower limit phase value
and the upper limit phase value;

a step of eliminating an offset component included
in the corrected differential value from the corrected
15   differential value output by the step of correcting
the differential value of the instantaneous phase, and
outputting a differential value from which the offset
component has been eliminated; and

a step of determining a jitter amount of the
20   signal to be measured by integrating the differential
value which is output by the step of eliminating the
offset component, and from which the offset component
has been eliminated.

15.   The jitter measuring method according to
25   claim 14, wherein

a lower limit and an upper limit of the range
dependent on the lower limit phase value and the upper

limit phase value are respectively equal to or
approximately equal to the lower limit phase value and
the upper limit phase value.

16.   The jitter measuring method according to
claim 14 or 15, wherein

the step of correcting the differential value of
the instantaneous phase has

a step of detecting the differential value of the
instantaneous phase as a discontinuous point of the
differential value of the instantaneous phase when the
differential value of the instantaneous phase detected
by the step of detecting the differential value of the
instantaneous phase is over the range dependent on the
lower limit phase value and the upper limit phase
value, and

a step of insuring continuity of the differential
value of the instantaneous phase by correcting the
discontinuous point of the differential value of the
instantaneous phase detected by the step of detecting
the discontinuous point of the differential value
of the instantaneous phase with respect to the
differential value of the instantaneous phase detected
by the step of detecting the differential value of the
instantaneous phase, and outputting the corrected
differential value.

17.   The jitter measuring method according to
claim 14 or 15, wherein

the step of correcting the differential value of the instantaneous phase has

a step of detecting the differential value of the instantaneous phase as a discontinuous point of the differential value of the instantaneous phase when the differential value of the instantaneous phase detected by the step of detecting the differential value of the instantaneous phase is over the range dependent on the lower limit phase value and the upper limit phase value, and

a step of eliminating the discontinuous point of the differential value of the instantaneous phase detected by the step of detecting the discontinuous point of the differential value of the instantaneous phase with respect to the differential value of the instantaneous phase detected by the step of detecting the differential value of the instantaneous phase, and outputting the eliminated differential value.

18. The jitter measuring method according to claim 14 or 15, wherein

the step of correcting the differential value of the instantaneous phase has

a step of detecting the differential value of the instantaneous phase as a discontinuous point of the differential value of the instantaneous phase when the differential value of the instantaneous phase detected by the step of detecting the differential value of the

instantaneous phase is over the range dependent on
the lower limit phase value and the upper limit phase
value, and

a step of substantially insuring continuity of
5   the differential value of the instantaneous phase by
eliminating the discontinuous point of the differential
value of the instantaneous phase detected by the step
of detecting the discontinuous point of the differen-
tial value of the instantaneous phase with respect to
10   the differential value of the instantaneous phase
detected by the step of detecting the differential
value of the instantaneous phase, and interpolating the
eliminated portion, and outputting the interpolated
differential value.

15   19.   The jitter measuring method according to
claim 14, wherein

the step of eliminating the offset component has
a step of storing a value determined by an
operation of $2\pi(fc/fs)$ showing the offset component in
20   a memory in advance when a frequency fc of the signal
to be measured and a sampling frequency fs for sampling
the signal to be measured have been already known, and
a step of subtracting the value showing the offset
component stored in the memory from the corrected
25   differential value output by the step of correcting
the differential value of the instantaneous phase.

20.   The jitter measuring method according to

claim 14, wherein

the step of eliminating the offset component has

a step of determining a mean value of the

corrected differential value output by the step of

5   correcting the differential value of the instantaneous

phase as an offset component in advance when

a frequency fc of the signal to be measured and

a sampling frequency fs for sampling the signal to

be measured have been unknown, and

10   a step of subtracting the mean value of the

corrected differential value serving as the offset

component determined by the step of determining the

mean value of the corrected differential value, from

the corrected differential value output by the step of

15   correcting the differential of the instantaneous phase.

21.   The jitter measuring method according to

claim 14, wherein,

when a lower limit frequency fj of a jitter

component which is an object to be detected is

20   designated, the step of eliminating the offset compo-

nent uses a high-pass filter which has a frequency

equal to or approximately equal to the lower limit

frequency fj of the jitter component which is the

object to be detected as a cutoff frequency for

25   eliminating the offset component from the corrected

differential value output by the step of correcting

the differential value of the instantaneous phase.

22. The jitter measuring method according to claim 14, wherein,

given that a digital signal sequence of the signal to be measured is x(n), a frequency and an amplitude of the signal to be measured are respectively fc and Ac, a sampling frequency for sampling the signal to be measured is fs, and an initial phase and a jitter of the signal to be measured are respectively θc and φ(n), n=0,1,2, ..., and when I(n), Q(n) serving as the two orthogonal signals are respectively expressed by

$$I(n)=x(n)=Ac·\cos [2\pi(fc/fs)n+\theta c+\phi(n)],$$

$$Q(n)=Ac·\sin [2\pi(fc/fs)n+\theta c+\phi(n)],$$

and Θ(n) serving as the instantaneous phase is expressed by

$$\Theta(n)=\tan^{-1} [Q(n)/I(n)]$$

$$=2\pi(fc/fs)n+\theta c+\phi(n),$$

the step of calculating the instantaneous phase calculates Θ(n) serving as the instantaneous phase determined by an operation of the $\tan^{-1} [Q(n)/I(n)]$ within a range from $-\pi$ to π, or $-\pi/2$ to $\pi/2$ as a range between the lower limit phase value set in advance and the upper limit phase value set in advance.

23. The jitter measuring method according to claim 22, wherein

the step of detecting the differential value of the instantaneous phase calculates ΔΘ(n) serving as the differential value of the instantaneous phase

calculated by the step of calculating the instantaneous

phase, by an operation of

$$\Delta\Theta(n)=\Theta(n)-\Theta(n-1)$$

$$=2\pi(fc/fs)+\phi(n)-\phi(n-1) \quad (\text{Where, } \Theta(n-1)=0, \text{ and}$$

here, $2\pi(fc/fs)$ is a constant and an offset component).

24. The jitter measuring method according to

claim 23, wherein

the step of correcting the differential value

of the instantaneous phase carries out arithmetic

processing of

$$\Delta\theta(n)=\Delta\Theta(n) \qquad\qquad (-\pi\leq\Delta\Theta(n)\leq\pi),$$

$$\Delta\theta(n)=\Delta\Theta(n)+2\pi \qquad (-\pi>\Delta\Theta(n)),$$

$$\Delta\theta(n)=\Delta\Theta(n)-2\pi \qquad (\Delta\Theta(n)>\pi)$$

or

$$\Delta\theta(n)=\Delta\Theta(n) \qquad\qquad (-\pi/2\leq\Delta\Theta(n)\leq\pi/2),$$

$$\Delta\theta(n)=\Delta\Theta(n)+\pi \qquad (-\pi/2>\Delta\Theta(n)),$$

$$\Delta\theta(n)=\Delta\Theta(n)-\pi \qquad (\Delta\Theta(n)>\pi/2)$$

with respect to $\Delta\Theta(n)$ serving as the differential value

of the instantaneous phase in order to calculate $\Delta\theta(n)$

serving as the corrected differential value corrected

so as to insure continuity by correcting a discontinu-

ous point of $\Delta\Theta(n)$ serving as the differential value

of the instantaneous phase calculated by the step of

calculating the instantaneous phase.

25. The jitter measuring method according to

claim 24, wherein the step of eliminating the offset

component eliminates the offset component $2\pi(fc/fs)$

from $\Delta\theta(n)$ serving as the corrected differential value corrected so as to insure the continuity by the step of correcting the differential value, and outputs

$$\Delta\phi(n)=\phi(n)-\phi(n-1)$$

5　　as $\Delta\phi(n)$ serving as the differential value from which the offset component has been eliminated.

　　26.　The jitter measuring method according to claim 25, wherein

　　the step of integrating the differential value

10　　from which the offset component has been eliminated

　　carries out a following integration

$$U(n)=\Sigma\Delta\phi(i)$$ (Where, the symbol Σ denotes the sum total of $i=0,1,2, \ldots, n$, and here, provided that $U(n)$ is theoretically expanded, it is made to be

15　　$$U(n)=[\phi(0)-\phi(-1)]+[\phi(1)-\phi(0)]+$$
$$[\phi(2)-\phi(1)]+\ldots\ldots\ldots+[\phi(n)-\phi(n-1)]$$
$$=\phi(n)-\phi(n-1)$$

　　with respect to $\Delta\phi(n)$ serving as the differential value which is output by the step of eliminating the

20　　offset component, and from which the offset component has been eliminated,
and here, given that $\phi(-1)=0$, an integrated result $U(n)$ is to express a jitter component $\phi(n)$ of the signal to be measured, and

25　　outputs the integrated result $U(n)$ as the jitter component $\phi(n)$ of the signal to be measured.